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ABSTRACT

Two sources of information are involved in reading; the visual information picked up by the eyes from the printed page and the nonvisual information, or prior knowledge, that the reader possesses. An overreliance on visual information leads to an overloading of the cognitive process involved in reading and loss in comprehension. Overreliance on visual information may result when a reader (1) has inadequate nonvisual information, (2) is expected to put too much visual information into memory, or (3) is too concerned over the prospect of missing some information or of making a mistake. Any of these three preceding conditions can in effect make reading impossible for an otherwise competent reader. (Author)

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OVERLOADING THE COMPETENT READER

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Abstract

Two sources of information are involved in reading; the visual information picked up by the eyes from the printed page, and the nonvisual information, or prior knowledge, that the reader already possesses. An overreliance on visual information leads to an overloading of the cognitive process involved in reading and a loss in comprehension. Overreliance on visual information may result when a reader (1) has inadequate nonvisual information, (2) is expected to put too much visual information into memory, (3) is too concerned over the prospect of missing some information or of making a mistake. Any of the three preceding conditions can in effect make reading impossible for an otherwise competent reader.

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It is often thought that reading is something of a passive activity; that the author is the person who is supplying all the information, or knowledge, and that the reader will have the message delivered to him if he looks at the words on the page in the right order and with sufficient application.

However, two quite different sources of information are in fact critical to the reading process, one source being the author (and the printer) who provides what may be called visual information - the ink marks on the page - and the other source the reader himself, who provides nonvisual information. Put in another way, reading involves the mixture or interaction of information that the reader receives through his visual system and information that he already has available in his head, behind the eyeballs.

Suppose, for example, that a book is written in a language that the reader does not understand; obviously there will be very little reading. Knowledge of the language is crucial nonvisual information that the reader himself must supply. Similarly, very little reading will take place if the subject matter of the text is completely removed from the experience of the reader - an article on subatomic physics for most teachers of English, or a life-on-the-farm story for an urban child. Obviously a good deal of prior knowledge is required if any piece of text is to be read; everything the author takes for granted must be supplied by the reader in the form of nonvisual information.

The distinction between visual and nonvisual information in reading is important because there is reciprocal relationship between them - readers can trade-off one for the other. The more nonvisual information a reader can use, the less visual information he needs. And the less nonvisual information a reader can supply, the more visual information

he must get from the page. Some aspects of this reciprocal relationship are immediately apparent - we read faster when the material we read is familiar, we can read smaller type, and in a dimmer light. We recognize familiar names and words over a greater distance than unfamiliar ones. On the other hand we tend to peer more closely, and read slower, when the going is hard, when our own contribution to the understanding of what we are reading is limited.

This use of nonvisual information to facilitate the work of the eyes is reflected in the way all readers make use of redundancy. (Redundancy means information to which you need not pay attention because you have it already). If a passage is redundant because the plot is predictable, or because the sentences are simple and almost everything is said more than once, then less visual information is required, and reading is easier.

This fact that there is a trade-off between visual and nonvisual information in reading is absolutely critical because there is a limit to the rate at which the brain can handle incoming visual information. This limitation is often overlooked because we tend to think that we see everything that happens before our eyes. We are not usually aware of the fact that the function of the eyes is simply to pick up and transmit information from the visual world to the brain, and that it is the brain that has the job of making the perceptual decisions about what we see. And there is a limit to how fast and how much visual information can be handled by the brain.

For example, it is impossible from a single glance - from what in reading is called a fixation - to identify more than four or five different things. More visual information may be available to the eyes, but four or five identifications is as much as the brain can manage from a single fixation. If a reader is allowed

just one glance at a sequence of random letters, for example, he will be able to identify no more than four or five of them. This is one of the oldest findings in experimental psychology. And it will take him all of one second to identify these letters. It is not necessary of course for the reader to be looking at the letters for the entire second, in fact a glimpse lasting no more than five thousandths of a second is usually more than enough for the eye to transmit to the brain all of the visual information it is going to be capable of handling for a second. For this reason, attempting to speed up the rate of fixation from the four or five a second that a child - and any other reader - normally makes is a pointless endeavor, since the informational bottleneck is in the brain and not the eye .

Of course, we can all read faster than the rate of four or five letters a second (which would work out to a reading rate of barely 60 words a minute if we actually read words letter by letter). And in fact if the sequence of letters that we allow our reader to glimpse is made up into recognizable words, rather than being selected at random, then we find that from this single fixation he can identify a couple of words, comprising perhaps a total of 10 letters. In other words, if the letters that he is shown are organized into words, then he can identify twice as many in a single glance and in the same period of time. The eye does exactly the same amount of work in each of the two fixations, whether the letters it is inspecting are a random sequence or whether they form words that the reader knows. But on the second occasion the reader can make use of nonvisual information, namely his knowledge of the way in which letters are organized into words.

It happens to be a fact that uncertainty about what a letter might be is reduced by half if that letter is part of a word - and the less the

uncertainty about what a letter is the less visual information is needed to identify it. If you can see that the first letter of a word is t, you know that the next is going to be h, r or a vowel, although if letters were occurring at random there could be any one of 26 alternatives. In other words, because of what you already know, because of nonvisual information, you require less new information to decide what a letter is when you are looking at words that you can read.

(Note that it is the prior knowledge of the reader, his nonvisual information, that is the ultimate determinant of whether a sequence of letters is random or not. Is the sequence przyjezdzac random or not? The answer depends on whether you can read Polish. If you can, then one glance at the word would suffice for you to recognize it; if not, you would be unlikely to be able to report half of it.)

We have not finished with the economies the brain can attain in making one fixation's worth (or one second's worth) of visual information go as far as possible. If the words our reader is permitted to glimpse actually constitute a meaningful phrase he will on the average identify four of them, a total of 20 or more letters. In other words, if the reader can supply nonvisual information of a syntactic and semantic nature (his knowledge of the language and the world in general), he will be able to use the same amount of visual information - one glance - to identify over four times as many letters, 20 or more compared with four or five.

It is helpful to look at the preceding phenomenon - which is sometimes called the "span of apprehension" and in other contexts the "effective field of view" - from the opposite point of view. If a fluent reader is allowed a single glance at a long sentence - if he is in effect allowed one second of visual information processing time - he will be able to identify four or five words.

In effect he "sees" four or five words. (When we read faster than four or five words a second we are making even greater use of nonvisual information and not bothering to identify most of the words). However, if the reader is not able to make extensive use of nonvisual information, either because he has limited subject matter or language or reading knowledge, or - what to him amounts to the same thing - if the letters are organized randomly, then he will literally be unable to see more than five letters. The less nonvisual information he can supply, the less he is able to see. This is in fact a widespread phenomenon known as "tunnel vision". Jet pilots suffer from it when involved in the complex task of trying to land their planes; they are so overloaded by visual information that their effective field of view is very narrow. Beginning readers are prime victims of tunnel vision - the width of line they can actually see is tremendously constricted by the limited amount of nonvisual information they can supply, especially if the material they are confronted with is relatively nonsensical (which means low in redundancy or predictability) and when demands upon them for literal accuracy (emphasis on visual information) are high.

The fluent reader, on the other hand, is one who can make maximum use of nonvisual information - he uses all the redundancy that is available, guesses as much as possible, and relies to a minimum on visual information. Speed readers, who are so skilled that they can make their ration of visual information go as far as possible, are able to read entire pages in a couple of fixations.

Obviously, a student trying to read a book on a topic with which he is not familiar does not have very much nonvisual information at his disposal. He will tend to read slower and more hesitatingly than the teacher who knows the topic backwards. Reading, for such a student, might be compared with trying to read in the half-light for the teacher. Like the beginning reader, he is reading as if he is looking at the page through the wrong end of a telescope. Even if

the student can recognize words on sight, he will still need twice as much visual information to identify them as a reader with more nonvisual information - which in essence means more reading experience - at his command.

To fully appreciate the disruptive effect of the limitations of the visual system in reading, it is necessary to examine another aspect of cognitive function that exercises considerable limitations upon us all, that of memory.

We all realize that there is a severe limit to how much we can put into our working memory (which is also called "short term memory") whenever we try to hold a seven digit telephone number in our head. Unless we can put some kind of pattern to the number or to a sequence of letters (which is the same thing as making use of information that we have already memorized) there is a limit of some four or five to the number of items we can retain in this way. (The similarity between the four or five random letters that can be read in a single glance and the four or five items we can hold in short term memory is coincidental. These are two independent limitations on reading, not one . Rather more than five items can be held in short term memory if we are not concerned with remembering their order as well.)

The limitation of short term memory in effect restricts the number of things we can pay attention to at any one time. It is of the utmost importance, therefore, that we use our working memory efficiently. If we try to overload short term memory, if we attempt to fill it beyond its capacity, then for every additional item we try to put in, something will come out. And there are only two fates for information that overflows from short term memory. Either it is put into our permanent memory store, which as I shall show is a time consuming business, or else it is lost altogether.

However, you have probably noticed that I used pretty vague and unscientific language in talking about the capacity of short term memory, just as I did when I talked about how much can be identified in a single glance - I used expressions like "four or five things". By now you probably have realized that a "thing", or item" as I have also called it, is a unit, the size of which is determined not so much by external considerations as by what the brain can do with it. In a single glance we can identify four or five random letters or a meaningful sequence of four or five words. Similarly we can load up short term memory with four or five letters or four or five words, or even with something that is far more difficult to specify precisely, several larger chunks of meaning. We know this "chunking" is possible because we can hold in short term memory the meaning - but not the exact words - from utterances of a dozen words or more. You can probably give the gist of the last couple of sentences you have read, although you have not had time to put it into permanent memory and you could not repeat the exact words from which you extracted that underlying meaning.

Obviously, to read fluently you must be able to use short term memory efficiently, which means to fill it with items that carry as much meaning as possible. If you are reading with tunnel vision, and can put into short term memory only meaningless sequences of letters or fragmented words, there is not a hope that you will be able to read with comprehension. In other words, unless you are able to make fluent use of nonvisual information, which is what provides the meaningfulness for what you read, you are going to be defeated from the start by the limitations of short term memory.

The handicap provided by the bottleneck in short term memory becomes even more obvious when one considers the limitations of long term memory - the permanent memory where in effect we organize and store all our knowledge of the world. Information that goes into long term memory is not transitory like that in short term memory, but rather there appears to be a permanent chemical change in the molecular structure of the brain. Similarly, long term memory appears to be practically infinite in capacity; it suffers from none of the limitations of size and duration of short term memory. However, having something in long term memory is no guarantee that we can get it out again, as we all know. Sometimes only an analyst's careful and persistent verbal probing - and occasionally the stainless steel probe of the brain surgeon - will give us access to our earliest memories. Generally the question of whether we can recover information from long term memory depends on how well we have it organized and how efficient are the memory probes that we send down to find and retrieve it.

However, we are more concerned at the moment with the rate at which new information can be put into long term memory, which is very slow and limited indeed compared with the more volatile short term memory. From three to five seconds is required to put one item of information into long term memory - whether the one item of information is a letter, a word or an entire chunk of meaning.

Some of the implications of the limitations of the visual system and of short and long term memory are particularly critical for reading and have been spelt out in some detail elsewhere.[1] For example, it is

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[1] For further discussion of the main points raised in this paper see Frank Smith, Understanding Reading New York; Holt, Rinehart and Winston, 1971, and Psycholinguistics and Reading New York; Holt, Rinehart and Winston, in press; also Frank Smith and Deborah Lott Holmes, "The independence of letter, word, and meaning identification in reading," Reading Research Quarterly, Spring 1971.

probably impossible to read with comprehension at slower than 200 words a minute - the units we are trying to get into short and long term memory will be too small and fragmented to be of any use. Similarly it is impossible to read for meaning if we stop to read every individual word; short term memory will soon overflow with a meaningless clutter of disconnected words and bits of words, and it would be most impractical to try to cram such "information" into long term memory.

Fluent reading requires the constant making of hypotheses about meaning in advance that are tested with a minimum of visual information, rather than analyzing every bit of visual information on the page and trying to strain it through the narrow sieves of memory. Most children know this (tacitly) when they begin to learn to read, that is why they will skip difficult words and guess, aiming to grasp the general meaning rather than every word. In this sense a child learning to read behaves very much like the fluent reader. The source of this "prior knowledge" that seems to guide a child's early reading efforts - until we train it out of him - is no mystery; the fact that his visual system and memory become so rapidly overloaded makes him realize it is impossible to read in the overprecise way adults often expect. However, when the time comes for a student to be expected to read books "for information", he may find that he is expected to acquire and store far more visual information than he can cope with, or he may have developed the crippling reading habit of trying to get more information from the text than his memory systems can handle.

The classroom practice of "testing" reading by asking numerous "comprehension" questions is basically an imposition upon long term memory. Pressure upon a reader to put more information through the slow and narrow entry into long term memory may have the reverse effect; short and long term

memories become jammed with trivial and incoherent pieces of information and as a result the reader understands and remembers less. For this reason many books that a student of any age might read of his own volition out of school become unreadable within the educational context. It is not that the student has less motivation to read and remember, but that the book literally becomes harder to read. The more a reader expects to be asked questions on what he reads, the more he will rely on visual information, and the more difficult will reading become. Similarly, additional physical effort is involved when we are confronted with a book on a topic with which we are unfamiliar, although a specialist in that subject might read the same book with speed and facility. To the specialist (who in classroom contexts is usually the teacher) there is a good deal of redundancy in subject area texts (because the specialist knows the subject already). And redundancy, as I have said, is the basis of fluent reading. Inability to make use of redundancy, through the lack or inaccessibility of nonvisual information, provides an insurmountable obstacle for a reader in unfamiliar territory.

One final point about reading. In any situation where an individual is anxious, or unsure of himself, or has experienced an unhappy succession of "failures", his behavior exhibits an inevitable consequence - he demands far more information before he makes a decision. His very hesitancy aggravates his difficulties. A similar dilemma confronts anyone trying to read in a condition of anxiety, regardless of the material he is reading or his underlying reading ability. The more anxious he is, the less likely he is to rely on nonvisual information. The ironic consequence is that such demanding behavior

makes the probability of error and of misunderstanding greater rather than less. Where the relaxed individual sees order, tenseness creates visual confusion. Whether the source of the unrealistic demand lies in the student himself or in the teacher, overdependence on visual information will overload the otherwise competent reader.